

What is claimed is:

Sub
A1

1. A diffractive optical element comprising:
a substrate on which a diffraction grating is formed, said diffraction grating having a level difference substantially perpendicular to a first surface of the
5 substrate; and
a dielectric multilayer film provided on the diffraction grating, wherein the layers included in said dielectric multilayer film are arranged such that only the same kind of layers are continuous across the level difference of the diffraction grating.

09988647 "112001

10 2. The diffractive optical element of claim 1, wherein said level difference has a height which is greater than the thickness of each individual layer of said dielectric film.

15 3. The diffractive optical element as claimed in claim 1, wherein a surface between adjoining level differences of the diffraction grating is inclined with respect to said first surface of the substrate.

4. The diffractive optical element as claimed in claim 1, wherein a surface between adjoining level differences of the diffraction grating is substantially parallel to said first surface of the substrate.

20 5. The diffractive optical element as claimed in claim 1, wherein said diffraction grating is a blaze type.

6. The diffractive optical element as claimed in claim 1, wherein said diffraction grating is a binary type.

09988647 112001

7. A diffractive optical element comprising:

a substrate on which a diffraction grating is formed, said diffraction grating having a level difference substantially perpendicular to a first surface of the substrate; and

5 a dielectric multilayer film provided on the diffraction grating wherein at least some of the dielectric layers included in said dielectric multilayer film are continuous across a level difference of the diffraction grating,

and wherein the level difference of the diffraction grating has a size that is an integral multiple of a thickness of one period of the dielectric multilayer film.

10 8. The diffractive optical element as claimed in claim 7, wherein said dielectric multilayer film has only two kinds of layers in one period, where n_0 is a refractive index of the substrate, n_1 and n_2 are refractive indices of the two kinds of layers of the dielectric multilayer film, and m is an integer not less than 1, and the following equation is satisfied:

15
$$2/n_0 = m (1/n_1 + 1/n_2).$$

9. The diffractive optical element as claimed in claim 8, wherein light is incident on a surface of the substrate where the diffraction grating is not formed.

20 10. The diffractive optical element as claimed in claim 7, wherein said dielectric multilayer film has only two kinds of layers in one period, where n_1 and n_2 are refractive indices of the two kinds of layers of the dielectric multilayer film, and m is an integer not less than 1, and the following equation is satisfied:

$$2 = m (1/n_1 + 1/n_2).$$

11. The diffractive optical element as claimed in claim 10, wherein light is incident on the surface of the substrate where the diffraction grating is formed.

Sub
A2

12. The diffractive optical element as claimed in claim 7, wherein said dielectric multilayer film has a number, j , of kinds of layers in one period, where n_0 is a refractive index of the substrate, $n_1, n_2 \dots n_j$ are refractive indices of the different kinds of layers of the dielectric multilayer film, and m is an integer not less than 1, and the following equation is satisfied:

$$2/n_0 = m (1/n_1 + 1/n_2 + \dots + 1/n_j).$$

13. The diffractive optical element as claimed in claim 12, wherein light is incident on a surface of the substrate where the diffraction grating is not formed.

Sub
A3

14. The diffractive optical element as claimed in claim 7, wherein said dielectric multilayer film has a number, j , of kinds of layers in one period, where $n_1, n_2 \dots n_j$ are refractive indices of the different kinds of layers of the dielectric multilayer film, and m is an integer not less than 1, and the following equation is satisfied:

$$2 = m (1/n_1 + 1/n_2 + \dots + 1/n_j).$$

15. The diffractive optical element as claimed in claim 14, wherein light is incident on the surface of the substrate where the diffraction grating is formed.

16. The diffractive optical element as claimed in claim 7, wherein a surface between adjoining level differences of the diffraction grating is inclined with respect to said first surface of the substrate.

20 17. The diffractive optical element as claimed in claim 7, wherein a surface between adjoining level differences of the diffraction grating is substantially parallel to said first surface of the substrate.

18. The diffractive optical element as claimed in claim 7, wherein said diffraction grating is a binary type.

19. The diffractive optical element as claimed in claim 7, wherein said diffraction grating is a blaze type.

5 20. A method of manufacturing a diffractive optical element,
comprising:
a first step of forming on a surface of a substrate a diffraction grating
having a level difference substantially perpendicular to a surface of the substrate;
and
10 a second step of forming a dielectric multilayer film on the diffraction
grating on the surface of the substrate so that only the same kind of dielectric
layers included in the dielectric multilayer film are continuous across the level
difference of the diffraction grating.

15 21. The method of claim 20 wherein said level difference has a height
which is greater than the thickness of each individual layer of said dielectric film.

22. The method of claim 20, wherein said dielectric multilayer film
comprises two kinds of layers, and further including the step of selecting materials
for said two kinds of layers which satisfy the following condition:

$$2/n_0 = m (1/n_1 + 1/n_2),$$

20 where n_0 is the refractive index of the substrate,
 n_1 is the refractive index of one kind of layer,
 n_2 is the refractive index of the other kind of layer, and
 m is an integer greater than zero.

23. The method of claim 20, wherein said dielectric multilayer film comprises j kinds of layers, where j is an integer greater than one, and further including the step of selecting materials for each of said layers which satisfy the following condition:

5
$$2/n_0 = m (1/n_1 + 1/n_2 + \dots + 1/n_j)$$

where n_0 is the refractive index of the substrate,

n_1 is the refractive index of one kind of layer,

n_2 is the refractive index of another kind of layer,

n_j is the refractive index of the j-th kind of layer, and

10 m is an integer greater than zero.

24. A diffractive optical element, comprising:

a substrate having a diffraction grating formed by periodic depressions and projections on a surface thereof; and

15 a dielectric film on said diffraction grating, said film comprising multiple layers of different kinds of dielectric material wherein at least some of said individual layers are continuous across plural successive depressions and projections of said diffraction grating.

25. The diffractive optical element of claim 24, wherein said level difference has a height which is greater than the thickness of each individual layer of said dielectric film.

20

26. The diffractive optical element of claim 24, wherein said diffraction grating is of the blaze type, and wherein each of said layers is continuous across at least two successive depressions and projections of said diffraction grating.

27. The diffractive optical element of claim 24, wherein said diffraction grating is of the binary type, and wherein at least some of said layers are continuous across all of the depressions and projections of said diffraction grating.

5 28. The diffractive optical element of claim 24, wherein said dielectric film comprises j different kinds of layers, where j is an integer greater than one, and the respective materials of said different kinds of layers satisfy the following condition:

$$2/n_0 = m (1/n_1 + 1/n_2 + \dots + 1/n_j)$$

where n_0 is the refractive index of the substrate,

10 n_1 is the refractive index of one kind of layer,

n_2 is the refractive index of another kind of layer,

n_j is the refractive index of the j-th kind of layer, and

m is an integer greater than zero.

29. The diffractive optical element of claim 25, where $j = 2$.

15 30. A diffractive optical element, comprising:

a substrate having a diffraction grating formed by a series of depressions in a surface of said substrate, each of said depressions having a predetermined depth; and

20 a dielectric film on said surface of the substrate, comprising a plurality of layers of different kinds of materials arranged in a periodic manner, said layers having a thickness such that said predetermined depth is an integral multiple of one period of said layers.

31. The diffractive optical element of claim 30, wherein said dielectric film comprises j different kinds of layers, where j is an integer greater than one, and the respective materials of said different kinds of layers satisfy the following condition:

$$2/n_0 = m (1/n_1 + 1/n_2 + \dots + 1/n_j)$$

where n_0 is the refractive index of the substrate,

n_1 is the refractive index of one kind of layer,

n_2 is the refractive index of another kind of layer,

n_j is the refractive index of the j-th kind of layer, and

m is an integer greater than zero.